A mode of interoperability with the ITER IMAS

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The US fusion program should establish a strong collaboration with the ITER integrated modeling program. Particularly, the US fusion modeling program can play an important role in the simulation, analysis and understanding of the burning plasmas in ITER and beyond. The development of predictive capability is one of the main goals of DOE-FES and this effort coordinated with colleagues in EU and ASIA can support ITER as well as our domestic program. The US has a significant lead in the application of high performance computing (HPC) codes to the fusion problem, and we should continue this in becoming leaders in producing a whole device model capability. Coupling to the ITER effort via the data object would seem more appropriate, e.g., a plasma-state to ITER Consistent Physical Objects (CPOs) translator or the like, to maintain and extend DOE's investment in HPC computer codes and their resulting reduced models.

The US integrated modeling approach should consist in two main parts: (i) to develop advanced and sophisticated numerical tools and (ii) to develop robust and "accurate enough" reduced models. The former is crucial to be able to fully understand and study/predict the high performance and ultimately the burning plasma and the latter is very important to be able to have accurate answers/predictions in a reasonable amount of time. In the long term, this last aspect could play an important role when numerical predictions will be requested / necessary between discharges.

Based on past experience with the Alcator C-Mod, NSTX, DIII-D and TFTR programs, support of the following critical program elements will insure that the required quantitatively accurate simulation and analysis codes will be available for the planning and subsequent analysis of ITER discharges by the end of the next decade when ITER operations are anticipated to commence:

1. Refinement of the physics in the codes to specifically address issues of importance to ITER will provide more quantitatively accurate predictive simulations of ITER discharge evolution and plasma performance;

2. More extensive validation of the code predictions against experimental measurements from domestic and international facilities;

3. A team of physicists working in concert with applied mathematicians and software experts is needed to make the source modules user friendly, well documented and robust for use by the

world fusion community and in the ITER IMAS framework. Indeed, by expanding the number of users of these codes worldwide, we anticipate that needed physics upgrades and algorithm improvements will be identified more quickly and included in the source models;

4. Coordination with our international partners in the EU and Asia will insure that the best simulation packages are assembled, using expertise developed in the EU and Asia as well as in the US.

Without this effort to actively engage with the international community, the impact of the US effort will most likely be largely ignored by the international fusion community and our role in the analysis of ITER discharges will likely be marginalized. Even if the US continues its current effort to identify and include physically realistic models for important processes that govern the evolution of plasmas, the use of these complex advanced models in the world community for the next generation of devices will be compromised without the direct participation of the US in the source development and applications in the ITER Modeling and Analysis Suite (IMAS) framework. It is well known that it is difficult to adapt and utilize such codes without direct collaboration with the authors of the codes. Our international partners may find it more expedient to use source models that are not as advanced as ours but for which direct support is available, or to develop such models themselves at the expense of a slow down in the progress of the overall program capabilities. Conversely, by working closely with our international partners on the development and utilization of these advanced modules in the IMAS infrastructure, the US will be in a position to "exert long term leadership" in "the science of prediction and control of burning plasmas ranging from the strongly RF driven to the self-heated state" [quote from presentation by Dr. Ed Synakowski, April 9, 2014 presentation to FESAC, pg. 5]. Coordination with our international partners in the EU and Asia will insure that the best simulation packages are assembled, using expertise developed in the EU and Asia as well as in the US. This international collaboration is required to build the international relations over the next decade that is crucial to the teamwork needed for the success of ITER.

In summary, the US fusion program should seize the opportunity to play a key proactive role in the simulation, analysis and understanding of the high performance and ultimately burning plasmas in ITER by expanding its physics modeling program to focus on the development, validation, and implementation of specialized, experimentally validated source modules towards a whole device model capability able to "communicate" with the IMAS framework. These source models are essential if one wants to accurately predict the evolution of ITER plasmas and understand the transport and stability processes that control the evolution of a burning plasma discharge in ITER. As a result of undertaking the initiative described here, the US will develop the tools and the international working relations required to fully participate in the simulation and analysis of ITER plasmas over the next decade and beyond, when ITER operations are anticipated to commence. This effort will also support the development of advanced models that will be needed in our domestic programs, as well as in supporting our collaborations on the long pulse devices such as KSTAR and EAST that are now beginning operations in Korea and China, respectively. The knowledge gained will also be valuable in the planning of future devices such as Quasar, ADX, FNSF and DEMO.